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EPA

Chemical Dehalogenation Treatability Studies Under CERCLA: An Overview

Office of Emergency and Remedial Reponse
Hazardous Site Control Division OS-220W

Quick Reference Fact Sheet

Section 121(b) of CERCLA mandates EPA to select remedies that "utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable" and to prefer remedial actions in which treatment "permanently reduces the volume, toxicity, or mobility of hazardous substances, pollutants, and contaminants as a principal element." Treatability studies provide data to support treatment technology selection and should be performed as soon as it is evident that insufficient information is available to ensure the quality of the decision. Conducting treatability studies early in the remedial investigation/feasibility study (RI/FS) should reduce uncertainties associated with selecting the remedy, and provide a sounder basis for the Record of Decision (ROD). Treatability studies conducted during remedial design/remedial action (RD/RA) provide data to support remedy implementation. Regional planning should factor in the time and resources required for these studies.

This fact sheet provides a summary of information to facilitate the planning and execution of chemical dehalogenation treatability studies in support of the RI/FS process. Detailed information on these pre-ROD treatability studies is provided in the *Guide for Conducting Treatability Studies Under CERCLA: Chemical Dehalogenation*, EPA/540/R-92/013a, May 1992. This technology-specific guide was designed to be used in conjunction with the final generic *Guide for Conducting Treatability Studies Under CERCLA*, which provides general information on the planning and execution of pre- and post-ROD treatability studies. Although some information on post-ROD chemical dehalogenation testing is provided here, the focus of this fact sheet and the chemical dehalogenation guide is on pre-ROD treatability studies.

TECHNOLOGY DESCRIPTION AND PRELIMINARY SCREENING

This fact sheet presents information on conducting treatability studies involving direct chemical dehalogenation of halogenated organics in soils, sediments, and sludges. For the purposes of this document, chemical dehalogenation includes those processes in which 1) a chemical reagent is applied directly to the contaminated matrix (soil or sludge), and 2) the reagent reacts with the contaminant to effect the removal of one or more halogen atoms from a molecule of the contaminant. The reaction between the reagent and the contaminant may be a substitution reaction (in which the halogen atoms are replaced by other atoms or chemical groups) or an elimination reaction [in which the halogen atoms and other atoms (e.g., hydrogen) are simultaneously removed from an aliphatic compound and form a double or triple bond in the molecule]. Examples of direct chemical dehalogenation include the alkaline polyethylene glycolate (APEG) processes and base-catalyzed decomposition (BCD) processes; they do not include desorption or extraction processes followed by chemical treatment of the condensate or extraction medium.

Chemical dehalogenation technologies that use an alkaline glycolate or base-catalyzed reagent are applicable to halogenated aromatic compounds, including PCBs, PCDDs, PCDFs, chlorobenzenes, chlorinated phenols, organochlorine pesticides, halogenated herbicides, and certain halogenated aliphatics (e.g., ethylene dibromide, carbon tetrachloride, chloroform, and dichloromethane). If other volatile organic, semivolatile organic, or metal contaminants are present, chemical dehalogenation can be used in conjunction with other technologies, such as low-temperature thermal desorption, solvent extraction, or biodegradation, as part of a treatment train. Chemical dehalogenation technologies are applicable to soils, sludges, and sediments. Treatment effectiveness depends on thorough mixing of the contaminants and treatment reagents, which requires that the waste matrix be excavated; in situ applications of the technology are not likely to be effective. Treated soils and residuals from chemical dehalogenation treatment may require posttreatment (e.g., neutralization) prior to their final disposition.

Chemical dehalogenation treatment is largely a vendor-controlled market comprising a number of patented, proprietary processes. Firms currently offering full-scale, alkaline glycolate remediation services (direct soil treatment or as

part of a treatment train) include Galson Remediation Corporation, SoilTech Inc., Chemical Waste Management Inc., and SDTX Technologies, Inc.

To date, chemical dehalogenation has been selected in the ROD for cleanup of contaminated soils at four Superfund sites: Wide Beach Development, Brant, New York (Region II, August 1985); Re-Solve, Inc., North Dartmouth, Massachusetts (Region I, July 1987); Sol Lynn/Industrial Transformers, Houston, Texas (Region VI, March 1988); and Myers Property, Hunterdon County, New Jersey (Region II, September 1990).

Prescreening the Technology

Potentially applicable process options are screened based on three factors: effectiveness, implementability, and cost. Table 1 presents the site and technology data that are required to screen the chemical dehalogenation process. The effectiveness evaluation focuses on 1) the potential for the process option to treat the estimated volume of contaminated media and to achieve the remediation goals identified in the remedial action objectives, 2) the potential impacts on human health and the environment during construction and implementation of the option, and 3) the documented performance of the option for treating similar contaminants and matrices. Implementability addresses both the technical and administrative aspects of implementing a process option. The cost analysis is made on the basis of engineering judgment and past treatment operations. This evaluation is crude, and its results alone will not be adequate to eliminate innovative process options such as chemical dehalogenation from further consideration.

USE OF TREATABILITY TESTS IN REMEDY SELECTION

The Process of Treatability Testing in Selecting a Remedy

As site and technology information is collected and reviewed, additional data needs for evaluating alternatives are identified. Treatability studies may be required to fill these data gaps. If so, treatability studies must be scoped and initiated as early as possible to keep the RI/FS on schedule and within budget.

The final generic *Guide for Conducting Treatability Studies Under CERCLA* details the three tiers of treatability testing (remedy screening, remedy selection, and remedial design/remedial action) and their relationship to the RI/FS and RD/RA processes. The three tiers are described here.

1) Remedy Screening—Small-scale studies performed in the laboratory that provide gross performance data for feasibility evaluation. They are characterized by:

   - Relatively low cost
   - Short amounts of time to perform
   - Less stringent quality assurance/quality control (QA/QC)

2) Remedy Selection—Small-scale studies performed in the laboratory or field that provide detailed performance and cost data for remedy selection. They are characterized by:

Table 1. Data collection requirements for prescreening the chemical dehalogenation process option.

Required Data	Prescreening Criteria
Effectiveness	
Contaminated media type	Applicable to soils, sludges, and sediments.
Volume of contaminated media	Cost-effective for volumes greater than 1000 m^3.
Contaminant type	Applicable to halogenated aromatics and aliphatics (PCBs, PCDDs/PCDFs, chlorobenzenes, chlorinated phenols, organochlorine pesticides, halogenated herbicides).
Contaminant concentration	Applicable to concentrations of parts per million or greater.
Past performance on similar wastes	Demonstrated applicability for waste contaminants and matrices should be available in the literature.
Implementability	
Availability of process	Should be a commercially available process.
Administrative	Necessary permitting requirements should be achievable; necessary treatment, storage, and disposal services should be available; equipment should be readily available.
Accessibility of site	Site should have adequate accessways and space to set up large trailer-based equipment and staging areas for excavated soil.
Cost	
Relative capital and O&M costs	Cost estimates, based on engineering judgment and historical costs, should be comparable to other options.

- Moderate cost
- Moderate amounts of time to perform
- Stringent QA/QC

3) Remedial Design/Remedial Action—Post-ROD, pilot-scale studies performed in the field that provide scale-up and design optimization data. They are characterized by:

   - High cost
   - Long amounts of time to perform
   - Moderately stringent QA/QC

The flow diagram in Figure 1 traces the stepwise data reviews and management decisions that occur in the tiered approach to treatability testing. A detailed description of this approach is presented in the final generic guide.

Applicability of Treatability Testing to Chemical Dehalogenation

The three-tiered approach to treatability testing is designed to be flexible to meet site- and technology-specific needs. Some technologies, including chemical dehalogenation, may not be investigated at all three tiers. The applicability of the tiered approach to chemical dehalogenation treatability studies is outlined in Table 2 (see next page).

Literature Survey

The decision to perform a chemical dehalogenation treatability study is based on the available site characterization data, input from management, and the results of a literature survey. The purpose of the literature survey is twofold. First, it should identify potentially applicable dehalogenation processes that have been adequately demonstrated and that are commercially available. Second, it should obtain all existing treatability data that are relevant to the site's waste matrix and contaminants of concern.

Remedy-Screening Treatability Studies

Remedy screening is the first step in the tiered approach. Its purpose is to determine the potential feasibility of chemical dehalogenation as a treatment alternative for the contaminants/matrix of interest. A chemical dehalogenation process is potentially feasible if it can be shown that the chemical reactions occurring between the dehalogenation reagents and the contaminants have the potential to dehalogenate the waste adequately.

The need to perform screening studies of chemical dehalogenation processes is contaminant- and matrix-specific. For example, the feasibility of several proprietary processes for the treatment of PCBs and dioxins in various soil types has been established and is well documented in the literature. Therefore, screening studies of these processes will generally not be required when PCBs or dioxins are the contaminants of concern. When the treatment of other halogenated organics, such as chlorinated phenols or halogenated aliphatics, or other matrices, such as sediment are involved, however, screening studies may be required, particularly given the

Figure 1. Flow diagram of the tiered approach.

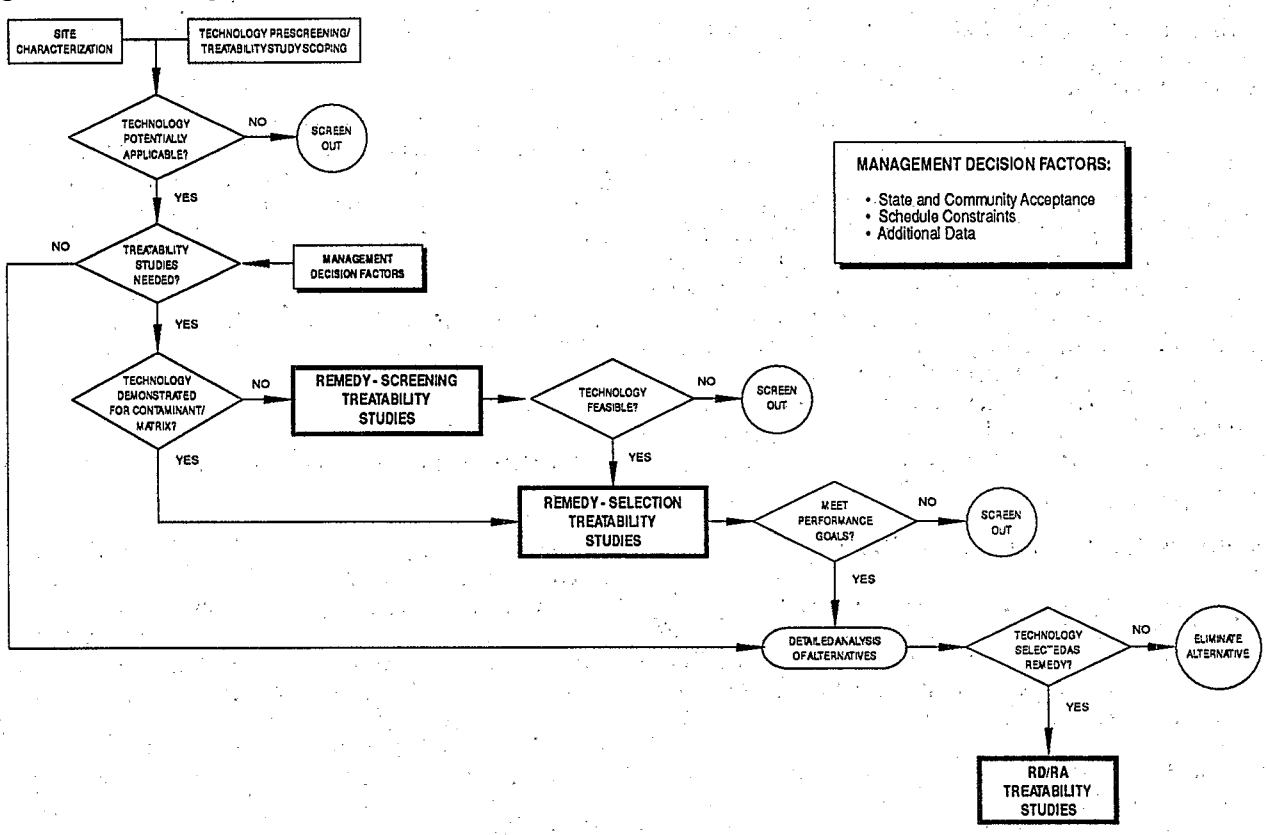

Table 2. Applicability of tiered approach to chemical dehalogenation treatability studies.

	Literature survey	Remedy screening	Remedy selection	ROD	RD/RA
Purpose	• Identify potentially applicable processes • Obtain existing treatability data	• Determine process feasibility for contaminants/matrix	• Generate performance and cost data for the detailed analysis of alternatives		• Generate scale-up, design, and cost data for implementation of selected remedy
Objective	• Determine treatability data needs	• Achieve >90% reduction in target contaminant concentrations	• Meet site cleanup criteria for target contaminants		• Optimize process
Parameters investigated	Not applicable	• "Severe" conditions	• Temperature • Reaction time • Reagent formulation/loading • Other process specific parameters • Sample type		• Feed rates • Mixing rates • Heating rates • Other equipment specific parameters
Data generated	Not applicable	• Concentration of target contaminants before and after treatment	• Effects of process parameters on target contaminant concentrations • Characteristics of product and residuals • Capital/O&M cost estimates		• Materials-handling characteristics • Reagent recovery/recycling efficiency • Energy/chemical usage • Treatment train performance • Residuals treatment performance

proprietary nature of chemical dehalogenation reagents.

Typically, remedy-screening treatability studies are conducted at the bench scale under "severe" conditions, based on available data and knowledge of the reaction chemistry. The concentrations of the target contaminants in the soil are measured before and after treatment to determine the efficiency of the dehalogenation process. Generally, this is the only measure of performance obtained at the screening tier.

The suggested performance goal for remedy-screening treatability studies is a 90 percent or greater reduction in the concentrations of the target contaminants. (Alternatively, site cleanup criteria can be used if they have been determined at this early stage in the RI/FS process.) If this goal is achieved, the process is considered a potentially feasible alternative and is retained for further evaluation. If greater than 90 percent reduction in the target contaminant concentrations cannot be achieved under the severe conditions of screening treatability studies, the process should be screened out.

Remedy-Selection Treatability Studies

A remedy-selection treatability study is designed to verify whether a chemical dehalogenation process can meet the site cleanup criteria and at what cost. The purpose of this tier is to generate the critical performance and cost data necessary for remedy evaluation in the FS.

Remedy-selection tests are normally conducted at the bench-scale and the concentrations of the target contaminants in the soil are measured before and after treatment to determine the efficiency of the dehalogenation process. At this tier, operating parameters are examined for their effects on target contaminant concentrations. A remedy-selection study should provide the RPM with enough information to ensure that the performance goals can be reliably met.

Performance goals for remedy-selection treatability studies should correspond to the anticipated remedial action objectives (cleanup criteria) for the site. If the dehalogenation process can achieve these cleanup criteria, it should be retained as an alternative for detailed analysis in the FS.

Data from remedy-selection tests can be used to characterize the product and residuals from dehalogenation treatment. Data generated at this tier can also be used to estimate the costs of full-scale implementation of the alternative, as required in the detailed analysis.

Remedial Design/Remedial Action Treatability Studies

Remedial design/remedial action is the final step in the tiered approach. The purpose of this tier is to generate detailed scale-up, design, and cost data for full-scale remediation. These treatability studies are conducted after the remedy has been selected and the ROD has been signed. In the implementation of a remedy, RD/RA treatability studies can be used 1) to select among multiple chemical dehalogenation processes and prequalify vendors of these processes, 2) to select the most appropriate of the remedies prescribed in a Contingency ROD, or 3) to support Agency-prepared de-

tailed design specifications for dehalogenation systems and treatment trains. Additional information on RD/RA treatability testing is available in the final generic guide.

Post-ROD studies conducted to support preparation of detailed design specifications for chemical dehalogenation typically generate data on materials-handling characteristics, reagent recovery/recycling efficiency, energy/chemical usage, treatment train performance, and residuals treatment performance. The parameters investigated at the RD/RA tier may include feed rates (continuous processes), number of treatment cycles (batch processes), mixing rates, heating rates, and other equipment-specific parameters. The objective of these studies is to optimize the process in terms of both performance and cost.

TREATABILITY STUDY WORK PLAN

Carefully planned treatability studies are necessary to ensure that the resulting data are useful for evaluating the feasibility, performance, and cost of a technology. The Work Plan, which is prepared by the contractor when the Work Assignment is in place, sets forth the contractor's proposed technical approach for completing the tasks outlined in the Work Assignment. It also assigns responsibilities and establishes the project schedule and costs. Table 3 presents the suggested organization of a treatability study Work Plan. Elements of a Work Plan that are specific to pre-ROD chemical dehalogenation treatability studies are discussed here. Information on the remaining elements can be found in the final generic guide.

Table 3. Suggested organization of treatability study work group plan.

1.	Project description
2.	Remedial technology description
3.	Test objectives
4.	Experimental design and procedures
5.	Equipment and materials
6.	Sampling and analysis
7.	Data management
8.	Data analysis and interpretation
9.	Health and Safety
10.	Residuals management
11.	Community relations
12.	Reports
13.	Schedule
14.	Management and staffing
15.	Budget

Test Objectives

The Work Plan outlines the treatability study test objectives and describes how these objectives will be used in evaluating chemical dehalogenation for selection at a site. Test objectives consist of meeting quantitative performance goals or making a qualitative engineering assessment of the process. Well-reasoned test objectives will ensure that the treatability study provides meaningful, scientifically sound data for remedy evaluation and selection

Experimental Design and Procedures

At the screening tier, the experimental procedures should not be complex. To reduce the risks of falsely screening out the technology at this early stage, the treatment should be carried out under "severe conditions"; i.e., the reaction should proceed with the use of excess reagent at a high temperature for an extended period of time. The particular reaction conditions used should be based on the process vendor's knowledge of the equipment and reaction chemistry. A single test run should be performed, and only limited QA/QC is required. Only pre- and posttreatment samples will be collected and physical and chemical analysis will be limited.

If chemical dehalogenation is determined to be potentially feasible at the remedy-screening tier, the effect of varying operating parameters on treatment performance can be investigated at the remedy-selection tier. Parameters that can be evaluated at this tier include reagent formulation and loading, temperature, reaction time, and other process-specific parameters. Duplicate or triplicate test runs should be performed, and a stringent level of QA/QC is required.

A remedy-selection treatability study must be designed to generate sufficient quantities of treated product and treatment residuals for characterization and posttreatment testing. If the dehalogenation process is part of a treatment train, the amount of treated material needed to investigate other train components must also be determined before the chemical dehalogenation study is designed.

Equipment

Remedy-screening studies normally are performed in a batch system using off-the-shelf laboratory glassware. A typical bench-scale reactor consists of a reaction flask, a stirrer, a heating mantel, and a condensate collection system.

Remedy-selection studies will be conducted in larger bench- or pilot-scale reactors. These systems may include ancillary equipment such as a feed preparation and delivery system, a steam plant, a reactant delivery system, and a soil/reagent separation system. Full-scale chemical dehalogenation treatment may generate several residual streams, including spent reagent and wash waters, condensate (aqueous and organic fractions), and process off-gases. The experimental design and procedures of a remedy selection treatability study should allow for investigations of these residuals.

To establish that the target contaminants were dehalogenated and not simply removed from the waste and transferred to the residuals, a material balance should also be designed and performed.

Permits

Treatability studies of chemical dehalogenation technologies are subject to certain regulatory requirements under Federal environmental laws. The final generic guide describes the permitting and operating requirements under

CERCLA and RCRA. Under the Toxic Substances Control Act (TSCA), laboratories or testing facilities that handle PCB-containing materials must obtain a Research and Development Permit. Storage of PCB-containing materials for purposes of treatability testing is limited to no longer than 1 year.

Residuals Management

Residuals generated as a result of chemical dehalogenation treatability testing must be managed in an environmentally sound manner. Early recognition of the types and quantities of residuals that will be generated, the impacts that managing these residuals will have on the project schedule and costs, and the roles and responsibilities of the various parties involved is important for their proper disposal.

Project residuals may include the following:

- Unused waste not subjected to testing
- Treated waste
- Treatment residuals (e.g., spent reagent, condensate)
- Laboratory samples and sample extracts
- Used containers
- Contaminated protective clothing and debris

Schedule

The duration of a chemical dehalogenation treatability study will vary with the level of testing being conducted. Remedy-screening studies can usually be performed within a few weeks. Remedy-selection studies, however, may require several months. In addition to the time required for actual testing, the schedule must allow time for obtaining approval of the various plans; securing any necessary environmental, testing, or transportation permits; shipping analytical samples and receiving results; seeking review and comment on the project's deliverables; and disposing of the project's residuals.

Budget

Elements of a budget include labor, administrative costs, and fees; equipment and reagents; site preparation and utilities; permitting and regulatory fees; unit mobilization; on-scene health and safety requirements; sample transportation and analysis; emissions and effluent monitoring and treatment; unit decontamination and demobilization; and residuals transportation and disposal.

The size of the budget will generally reflect the complexity of the treatability study. Consequently, the number of operating parameters chosen for investigation at the remedy-selection tier and the approach used to obtain these measurements will often depend on the available funding. The technology vendor should be consulted to obtain this kind of information during the planning of the treatability study.

Analytical costs can have a significant impact on the project's overall budget. Sufficient funding must be allotted for the amount of analytical work projected, the chemical and physical parameters to be analyzed, and the required turnaround time. Specialty analyses, such as for dioxins and furans, can quickly increase the analytical costs.

SAMPLING AND ANALYSIS

Factors associated with sampling and analysis that affect the development of the Work Plan and the Sampling and Analysis Plan (SAP) for chemical dehalogenation treatability testing are summarized here. A detailed discussion on the development of a SAP for remedy-screening and remedy-selection treatability studies, including a suggested plan organization, is contained in the chemical dehalogenation guide.

Field Sampling

The amount of sample collected should be based on the quantities needed for each test run and for pre- and posttreatment analyses as well as the number of test runs and replicate analyses to be performed. Bench-scale tests at the remedy-screening tier generally require small sample volumes (<1 L per test run). The increased number of test runs and the extent of pre- and posttreatment analyses for bench-scale, remedy-selection testing will require that a greater total waste sample volume be collected. Pilot-scale tests conducted in support of remedy selection will require much larger sample volumes (>100 L per batch). If the dehalogenation process is part of a treatment train, the volume of treated product and treatment residuals needed for later testing also will impact the total volume of waste to be collected.

Waste Characterization

Various chemical tests may be used to establish the baseline concentration of the target halogenated organic contaminants and other contaminants of interest. For remedy-screening studies, only one analysis for the target contaminants expected to be present in the untreated waste may be necessary. For remedy-selection studies, however, two or three replicate analyses may be required to establish the homogeneity of the waste and to determine statistical confidence levels for the target contaminant concentrations.

Additional compounds of interest at the remedy-selection tier may include selected possible halogenated byproducts from the degradation of the target contaminants. The selection of other halogenated organic compounds should be based on the likely chemical reactions and relative toxicity of the byproducts. Compounds that could interfere with the chemical dehalogenation process (e.g., elemental forms of certain metals) or those that affect treatment or handling of residual fractions from the process also may be of interest at the remedy-selection tier.

Soil moisture content and pH or buffering (base absorption) capacity should be determined at the remedy-screening and remedy-selection tiers. High-moisture-content soils may require greater quantities of reagent because of the dilution effects of the soil water. Acidic soils or soils with a high buffering capacity will require excess base to compensate for base-consuming reactions with the soil. Particle-size analysis of the soil is used to determine the experimental apparatus needed for mixing and soil/reagent separation. Bioassays of

the untreated waste may be required to establish baseline biotoxicity data if replacement of the treated product on site is being evaluated as a disposal option.

Treated Product and Residuals Sampling and Analysis

Posttreatment sampling and analysis at the remedy-screening tier will be limited to the target halogenated organic contaminants in the treated product. Posttreatment analytes at the remedy-selection tier may also include selected potential halogenated byproducts. Analysis for target and other contaminants of interest in the treatment residuals also may be necessary at the selection tier to demonstrate dehalogenation of the target contaminants rather than physical removal. This determination would require a careful accounting of the mass of all materials that enter and exit the system. The material balance, combined with the concentrations of target contaminants in all exit fractions, can then be used to refine the estimate of actual dehalogenation efficiency of the process.

In addition to chemical tests, physical and toxicological tests also may be conducted on treated product or treatment residuals at the remedy-selection tier to evaluate posttreatment and disposal options. If treated product is to be placed back into the original excavation (i.e., not in an onsite disposal cell), determination of its mechanical properties, pH, and nutrient levels and the leachability of remaining contaminants may be required. It is important to note that mechanical test methods may require significant quantities of soils (e.g., 20 kg); therefore, the vendor may be required to perform multiple test runs to generate sufficient quantities of material for analysis. Bioassays also may be required for evaluation of the toxic or mutagenic effects of chemical dehalogenation residuals on biota. Applicable tests include freshwater algae, daphnid, and minnow assays of product extracts and seed germination and earthworm tests of treated product.

TREATABILITY DATA INTERPRETATION

The purpose of a pre-ROD treatability investigation is to provide the data needed for detailed analysis of alternatives and, ultimately, the selection and design of a remedial action that can achieve the site cleanup criteria.

Use of pre-ROD Treatability Study Results in the RI/FS Process

The interim final *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, EPA/540/G-89/004, October 1988, specifies nine evaluation criteria to be considered in the assessment of remedial alternatives. These criteria were developed to address both the specific statutory requirements of CERCLA and the technical and policy considerations that are important when selecting among remedial alternatives. The nine RI/FS evaluation criteria are as follows:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

Table 4 *(see next page)* lists factors important to the analysis of the first seven of these criteria and the treatability study data that provide information for this analysis. The results of treatability studies also may influence the evaluations against the state and community acceptance criteria.

Use of Pre-ROD Treatability Study Results in the RD/RA Process

Pre-ROD treatability study results also provide information for the subsequent detailed design investigations of the selected remedial technology. Pre-ROD data on the chemical, physical, and toxicological characteristics of the treatment residuals will be useful in planning remedy design studies in which large volumes of residuals will be handled and disposed of. Problems encountered during remedy selection treatability studies—such as difficulties in mixing, heating, reagent separation and recovery, and health and safety—should be carefully documented for post-ROD pilot- and full-scale investigations.

TECHNICAL ASSISTANCE

The Office of Solid Waste and Emergency Response (OSWER) and the Office of Research and Development (ORD) established the Superfund Technical Support Project (TSP) to provide direct, technology-based assistance to the Regional Superfund programs through ORD laboratories. As part of the TSP, the Engineering Technical Support Center provides technical assistance in the planning, performance, review, and oversight of treatability studies. For further information please contact:

Engineering Technical Support Center
ORD/Risk Reduction Engineering Laboratory
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Table 4. Applicability of chemical dehalogenation treatability study data to RI/FS evaluation criteria.

Evaluation Criteria	Analysis Factors	Treatability Study Data
Long-Term Effectiveness and Permanence	Magnitude of residual risk	• Target contaminant concentrations in treated product and treatment residuals • Presence of specific reaction byproducts in treated product • Results of bioassays performed on treated product
Reduction of Toxicity, Mobility, or Volume Through Treatment	Reduction in toxicity	• Percent reduction in target contaminant concentrations • Comparison of bioassay results before and after treatment
	Irreversibility of the treatment	• Material balance data combined with target contaminant concentrations in treated product and treatment residuals
	Type and quantity of, and risks posed by, treatment residuals	• Target contaminant concentrations in treatment residuals • Presence of specific reaction byproducts in treatment residuals • Results of bioassays performed on treatment residuals • Volume of treatment residuals
Short-Term Effectiveness	Protection of community during remedial actions	• Physical/chemical characteristics of waste matrix • Physical/chemical characteristics of treatment residuals
	Protection of workers during remedial actions	• Physical/chemical characteristics of waste matrix • Physical/chemical characteristics of treatment residuals • Reagent formulation/material safety data
	Time until remedial response objectives are achieved	• Reaction time
Implementability	Reliability and potential for schedule delays	• Reliability and schedule delays during testing • Reaction time/throughput • Physical characteristics of waste matrix • Contaminant variability in untreated waste
Cost	Direct capital costs	• Reaction time/throughput • Reagent usage/recovery • Reaction temperature • Physical characteristics of waste matrix • Site characteristics
	Operation and maintenance costs	
	–Chemicals/reagents	• Reagent formulation/loading • Reagent usage/recovery • Volume and characteristics of treated product and treatment residuals
	–Utilities	• Reaction time/throughput • Reaction temperature
	–Residuals treatment/disposal	• Volume and physical/chemical characteristics of treatment residuals
	–Equipment	• Reaction time/throughput • Physical characteristics of waste matrix
	–Labor	• Reaction time/throughput
Compliance with ARARs	Chemical-specific ARARs	• Target contaminant concentrations in treated product and treatment residuals
	Location-specific ARARs	• Target contaminant concentrations in treated product and treatment residuals • Results of bioassays performed on treated product and treatment residuals
	Action-specific ARARs	• Target contaminant concentrations in treated product and treatment residuals
Overall Protection of Human Health and the Environment	Ability to eliminate, reduce, or control site risks	• Target contaminant concentrations in treated product and treatment residuals • Presence of specific reaction byproducts in treated product and treatment residuals • Results of bioassays performed on treated product and treatment residuals

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16. ABSTRACT

Systematically conducted, well-documented treatability studies are an important component of remedy evaluation and selection under the Superfund program. This manual focuses on chemical dehalogenation treatability studies conducted in support of remedy selection that is conducted prior to the Record of Decision (ROD).

This manual presents a standard guide for designing and implementing a chemical dehalogenation treatability study. The manual presents a description of and discusses the applicability and limitations of chemical dehalogenation technologies and defines the prescreening and field measurement data needed to determine if treatability testing is required. It also presents an overview of the process of conducting treatability tests and the applicability of tiered treatability testing for evaluation of chemical dehalogenation technologies. The specific goals of each tier of testing are defined and performance levels are presented that should be met at the remedy screening level before additional tests are conducted at the next tier. The elements of a treatability study work plan are also defined with detailed discussions on the design and execution of the treatability study.

17. KEY WORDS AND DOCUMENT ANALYSIS

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